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ELECTRICITY · ACETYLENE · OIL · GAS

Edited by LEON GASTER

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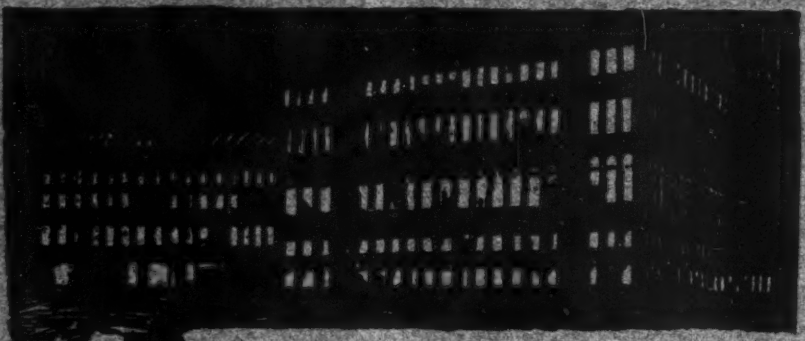
This number contains an Account of the Meeting of The Illuminating Engineering Society on January 22nd, 1924, when a discussion on **"Co-ordination of Research in Illuminating Engineering"** was opened by MR. J. S. DOW.

Also an account of the discussion opened by Messrs. J. F. CAINE and E. A. MARX, Jr., on February 19th, by an introductory paper entitled **"Some Notes on Traction Lighting by Electricity."**



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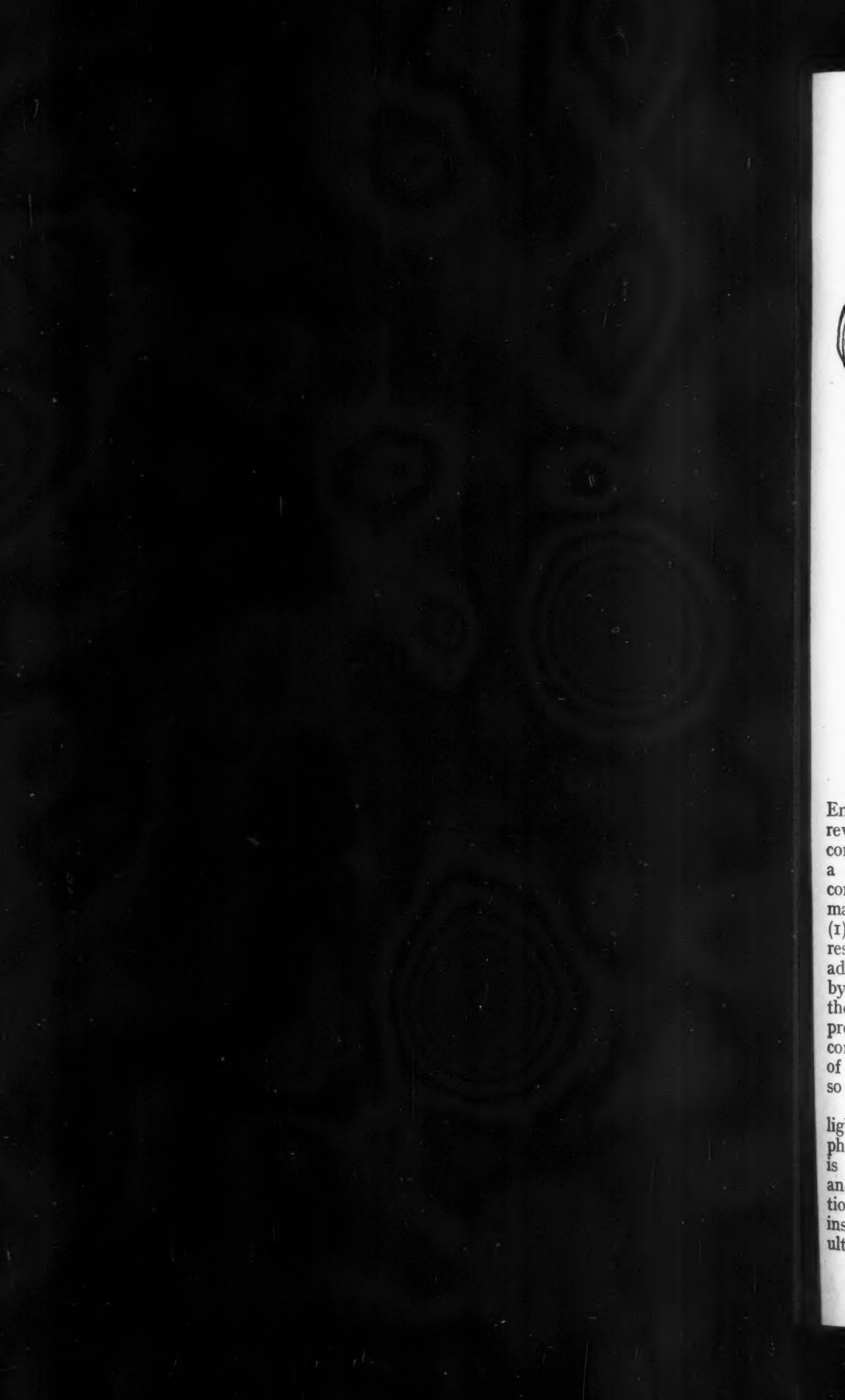

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EDITORIAL.

Research in Illuminating Engineering.

The paper read by Mr. Dow on this subject before the Illuminating Engineering Society on January 22nd contained a very comprehensive review of subjects for research—probably as wide a survey as could be conveniently presented in a single paper. Illuminating Engineering is a rapidly developing subject. New opportunities for experiment are constantly presenting themselves. Research in illuminating engineering may be classified in various ways, but four main divisions were recognised : (1) those that are primarily scientific and can be handled by colleges and research institutions ; (2) those that are essentially technical, for instance, advances in lamps and fittings, which naturally are developed most readily by manufacturers ; (3) those relating to applications of light, which demand the joint efforts of lighting experts and *users* of illumination ; and (4) those problems of a very wide character, of importance to large sections of the community, which should be dealt with by bodies or joint committees of recognised impartiality and of a thoroughly representative character so that their conclusions may bear the impress of authority.

One of the most obvious fields for experiment is in the measurement of light. In most sciences early work consists chiefly in observation of phenomena. Then we come to a more advanced stage when *measurement* is undertaken. This stage has been reached in illuminating engineering, and much valuable information has been gained by the aid of the illumination photometer. Nevertheless, there is room for improvement in such instruments, especially in respect of simplicity, and it is conceivable that ultimately we may be able to devise a direct-reading and very simple

instrument based on the use of photometric cells—though admittedly there are at present many difficulties to overcome.

There are many problems that are partly physical and partly physiological such as the study of effects of colour and "artificial daylight," the devising of convenient tests of glare, the effects of invisible rays. Nor should it be assumed that such researches need only relate to artificial light. After all we still spend the greater part of our time in daylight, and, as Mr. Waldram has shown, the investigation of access of daylight into buildings offers a fine field for the efforts of those who are familiar both with photometry and the practical side. In this subject the help of the architect is needed, just as the aid of the ophthalmic surgeon and physiologist are required in the problems previously mentioned. When we come to questions of artistic and decorative effect we come up against problems that do not involve "scientific" research in the ordinary sense, but require study just as much as purely technical matters. Here, as well as in problems affecting the influence of light in industry and for purposes of advertisement, we enter the field of yet another expert, the psychologist

Such problems as the lighting of streets, railways, mines, factories, etc., afford opportunities for almost unlimited research, and in almost all cases the co-operation of the user of light is needed. Conclusions formed affect large sections of the community, and, therefore, they must, in order to meet with ready acceptance, be backed by scientific and impartial authority. This is the kind of subject with which the Illuminating Engineering Society, with the help of kindred bodies, is particularly well-fitted to perform and initiate, and we are glad to note that it was generally accepted in the discussion that in this respect it can do a great deal more for manufacturers than they could hope to do for themselves.

The fundamental question is how best to get these innumerable researches done, without overlapping of effort—a very essential point. The developments of courses in illuminating engineering at colleges, and the proposed issue of a text book on the subject as a guide to teachers and students, should do much to create an atmosphere favourable to research. One of the most hopeful signs during recent years has been the readiness of other bodies to take up the burden of sections of this vast amount of work, and the continual opening up of new channels for experiment. In the newly-formed Committee on illumination working under the Department for Scientific and Industrial Research we have an organisation that is already doing good work and can deal with many problems of interest to the Society. At the National Physical Laboratory much valuable research has also been done. Various questions of national and international interest are being studied by the National Illumination Committee. The fact that the B.E.S.A. has recently appointed a Committee to deal with standardisation in the lighting industry is an indication that the pioneering stage has now been passed and that the time is ripe for constructive practical effort.

In all this work the Illuminating Engineering Society acts as a connecting link. It can itself undertake much useful research. But the field is too vast to be covered by one organisation and illuminating engineering demands the aid of everyone who can take a share in research. In the concluding portion of his paper Mr. Dow remarked that there is nothing in the way of research being done abroad that could not be equally well done in this country, if adequate support is forthcoming. We look to the lighting industry, which has benefited directly from the work so far done, to enable future efforts to be on a much large scale.

Problems in the Lighting of Trains, Trams and Buses.

The discussion before the Illuminating Engineering Society on February 19th dealt chiefly with the lighting of railway carriages, tramcars and public vehicles, though reference was made incidentally to other problems. A general desire was expressed for a higher order of illumination, several speakers emphasising the effect of well-lighted vehicles in attracting traffic. Passengers, undoubtedly, will select for preference a route on which they can read in comfort. As regards electric railways it is common knowledge that they obtain their current very cheaply, so that the cost of lamps is probably one of the chief items to be considered.

Attention was also directed to methods of shading. Whilst one recognises the difficulties—small overhead space, danger of breakage of shades by straphangers, etc.—we think that in principle bare lamps should not be used, involving as they do considerable glare, especially to those standing who receive the light almost at eye-level. We hope that the electrified railways will do their best to make improvements where circumstances demand; no doubt, any apparent slowness in doing so is due mainly to the difficulty of converting large masses of existing rolling stock. Naturally, the problem is simplified when the coach is designed with full consideration of lighting requirements, and we are glad to notice that on some of the latest models very greatly improved methods have been introduced, the freedom from glare arising from the use of cup-shaped reflectors of diffusing glass and the substantial improvement in illumination being noticeable features.

As regards the other points raised in the discussion Mr. Cunnington fully endorsed the importance of adequate standards for the lighting of platforms in main stations. This is certainly the first point to receive attention as the lighting of important stations is of much greater consequence than that of small way-stations, where there are not many passengers and trains are few and far between. Obviously, in advocating improvements in lighting one must make a judicious selection and try in the first place to direct attention to the most urgent problems, among the large number presented on modern railway systems.

Attention was also devoted to the illumination of station name-plates, a matter that well deserves study. Lighting fittings in leading railway stations should have a pleasing effect, besides being efficient. Equally important, both on railway systems generally and in carriages, is the use of fittings of simple design, easily maintained; very frequently such fittings have to be handled by men with little technical knowledge. Vibration again introduces special problems and the leading makers deserve credit for the progress made in the design of more robust and durable forms of lamps, as well as special fittings for railways. All these matters will no doubt receive attention in due course from the joint committee on railway lighting formed by the Society.

We were glad to note a general recognition that any large transport system, whether concerned with railways or public vehicles, should entrust lighting problems to an expert—naturally working in co-operation with other departments, but personally responsible for conditions of illumination. We feel sure that the wisdom of this step would soon be justified by improvements and saving of useless expenditure, the latter quite as important a duty as the initiation of advances in lighting, and by public appreciation of the comfort to passengers of better illumination.

Public Lighting.

The question of public lighting has been discussed in this journal on many occasions. It has been pointed out that the lighting of the metropolis varies greatly, some areas—such as the City of London—being well lighted while others are admittedly below the proper standard. Hence it has been suggested that the lighting of London as a whole ought to be supervised by a properly constituted central authority, which would study the relation between accidents and street lighting, decide the lighting requirements of different classes of streets, and conduct experiments on a large scale by which not only London, but other cities might benefit.

The importance now attached to the matter was aptly illustrated by the first meeting of the Institution of Public Lighting Engineers held at the Holborn Borough Council Offices on February 15th. The first President, Mr. S. B. Langlands, Lighting Engineer to the City of Glasgow, reviewed the problem in its wider aspects, and Captain W. J. Liberty, who is connected with the lighting of the City of London, gave an interesting account of methods adopted in this area. In the subsequent discussions representatives of various provincial cities took part, and the author, as a delegate from the London "Safety First" Council, pointed out the importance of the subject in relation to street accidents. The gas industry was well represented in the audience, and it appeared that the majority of the exhibits illustrated progress in public lighting by gas, though there were some electrical devices on view. Following the meeting many of those present took part in a tour by motor bus arranged with the object of giving a survey of lighting in some of the chief thoroughfares of London.

Exchange of views between those responsible for public lighting should have a good effect, and we hope that in course of time there will be a larger number of recognised public lighting engineers. We fully endorse the view that the lighting of a large city should be placed in the hands of a fully qualified expert, and not relegated to one who has many other duties, as is usually the case at present. Good lighting ought to be a matter for civic pride, and public authorities have a clear responsibility for street accidents that are due to inadequate illumination.

The services of fully qualified public lighting engineers are essential to the treatment of the problem on a national, rather than a parochial basis, for on their skill and knowledge rests the application of information gathered by a central authority. Moreover, the coming of the motor vehicle has radically altered the speed and volume of traffic on many arteries between cities, and the lighting both of these and new thoroughfares now contemplated or under construction will need careful thought. It is stated, for instance, that the plans for the new Manchester-London motor-way, are well advanced. Naturally, such a thoroughfare, specially designed for fast traffic, will require lighting very much better than that commonly allotted to country roads. This is another instance of the need for treating public lighting on national lines, and the Illuminating Engineering Society will gladly co-operate with other bodies interested in bringing home the importance of the subject.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

CO-ORDINATION OF RESEARCH IN ILLUMINATING ENGINEERING.

(Proceedings at the meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, W.C., at 8 p.m., on Tuesday, January 22nd, 1924.)

A MEETING of the Society was held at the House of the Royal Society of Arts (18, John Street, Adelphi, London, W.C.), at 8 p.m. on Tuesday, January 22nd, Mr. D. R. WILSON presiding.

The Minutes of the last meeting having been taken as read, the HON. SECRETARY read out the names of the following applicants for membership :—

Mr. W. A. BLISS	Elec. Engineer, 17, Dene Grove, Redcar, Yorks.
Mr. E. W. HARMER	Illuminating Engg. Dept., General Electric Co., Ltd., Kingsway, London, W.C.2.
Mr. W. HOLMES	Elec. Engineer, 31, Bruce Grove, London, N.17.
Mr. G. WARMAN	Superintendent, Elec. Lighting Dept., British Electric Co., 25, Lower Road, London, S.E.16.
Mr. THOMAS WILKIE	Superintendent of Public Lighting, Leicester Corporation, 84, Beaconsfield Road, Leicester.

The CHAIRMAN then called upon Mr. J. S. Dow to read his paper on **"Co-ordination of Research in Illuminating Engineering."** Mr. Dow attempted a rough classification of different forms of research showing how, whilst some were best undertaken by manufacturers, others could only be dealt with by an impartial body representing all aspects of illumination. Special reference was made to photometry, statistical data showing the relation between lighting conditions, accidents and production and the lighting requirements of various industries. Finally the author emphasised the need for better educational facilities in connection with illuminating engineering at technical colleges and the need for additional support in order that the Society might be able to carry out its work on a wider scale. An interesting discussion ensued in which Major K. EDGCUMBE, Mr. J. W. T. WALSH, Mr. W. R. RAWLINGS, Mr. P. J. WALDRAM, Mr. A. CUNNINGTON, Mr. A. BLOK, Mr. L. GASTER, and Mr. D. R. WILSON took part.

A vote of thanks having been accorded to the Author, it was announced that the **next meeting** would be held on **Tuesday, February 19th,** when there would be a discussion on **"Some Aspects of Railway Lighting."**

CO-ORDINATION OF RESEARCH IN ILLUMINATING ENGINEERING AND SOME PRACTICAL APPLICATIONS.

By J. S. Dow.

(Abstract of paper read at the meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 8 p.m., on Tuesday, January 22nd, 1924.)

INTRODUCTION.

IN a comparatively new subject, such as Illuminating Engineering, research necessarily plays an important part. From the very outset discussions before this Society have been fruitful in suggesting problems, which we have tried, more or less successfully, to solve. The very first discussion on "Glare: Its Causes and Effects," was typical in this respect. We have learned since a great deal about the causes of glare, but we are still to-day grappling with the problem of devising simple and easily applicable rules for its avoidance. Our next discussion on "The Measurement of Light and Illumination," undoubtedly gave a great stimulus to photometry and paved the way for the improved simple forms of illumination-photometers which have done such good service. Yet here again we have not reached finality, and no doubt existing apparatus is capable of improvement.

One of the most complete lists of problems awaiting investigation was that given in the report of the Society's Committee on Research, presented in May, 1916. Some of the points furnished instances of "intelligent anticipation" as the need for research has since become still more evident. Certain problems, such as the need for a satisfactory Primary Standard of Light, a Series of Standard Colours, and a Standard of "White Light," are obviously complex and difficult and will probably occupy our attention for some time to come. Others, such as the preparation of good heat-resisting glassware, the possibility of standardising parts of lamps and burners, etc., became acute during the war, and the justification for raising them became fully evident in the light of subsequent experience. Street lighting, even then, was suggested as a useful field for research, in preparation for the after-war period, when many systems, neglected during the war, would require renewal or reconstruction. On some of the subjects mentioned, such as the lighting of hospitals and picture galleries, useful contributions have since been made in the form of papers before the Society.

It may be recalled that a joint committee was formed under the Department for Scientific and Industrial Research to deal with illumination during the war. This committee was eventually dissolved, but, as recently announced, a new committee working under the Department was formed last year, and this should furnish a valuable means of dealing with many problems of interest to the Society. It is to be hoped that in the future facilities for research in illuminating engineering will be greater than at present, and it was therefore suggested to the writer that the time is opportune to review some of the problems now awaiting solution and consider how they can best be studied.

CLASSIFICATION OF RESEARCH.

In the first place it is desirable to make some broad classification of researches. This may be done in various ways. We must, for example, attach some importance to order *of urgency*. It is perfectly true that one can never foresee the practical results of any research in pure science and that many experiments, which originally seemed to be of purely scientific interest, afterwards proved to have extremely important practical applications. In this sense no research which adds to our knowledge of illuminating engineering is unimportant. But we are faced by a variety of problems, too great to be all pursued in detail. One is, therefore, disposed to emphasise those researches which seem likely to lead to useful results in the immediate future,

whilst recognising the importance of others that are not so likely to yield a practical return, and also obviously involve very prolonged effort.

For our purpose, the best mode of classification is perhaps based on the consideration, "By whom is the research to be undertaken?" Even on this basis no really hard and fast classification is possible. But the distinctions are sufficiently definite to aid us in co-ordinating research and exploring the best means of getting it carried out.

One might therefore divide researches somewhat as follows:—

(A) *Primarily scientific*, such as investigations on standards of light, photometry, systems of colour-nomenclature, physiological research on the effect of light and colour on the eye, etc.

(B) *Mainly technical*, such as efforts to improve the efficiency of illuminants, to devise special forms of globes and reflectors, and generally all kinds of lighting appliances used in practice.

(C) *Problems involved in the application of light*, such as are involved in deciding the best methods of lighting various kinds of buildings or streets and where the joint effort of the expert and the user of light is needed.

(D) *Problems of a very general character*, undertaken in the interests of the lighting industry as a whole and the public, which usually can only be effectively dealt with in co-operation with other bodies. A good instance of this form of problem is afforded by the determination of the conditions of lighting desirable in various industries.

Generally speaking, problems of type (A) would most readily be undertaken at colleges or educational institutions where laboratories are available, and at such institutions as the National Physical Laboratory. In the National Illumination Committee we have a body which is already doing excellent work in connection with units and nomenclature, while the International Illumination Commission deals with the same subjects on an international basis. Technical problems of type (B) are naturally undertaken mainly by manufacturers of lamps and lighting equipment, though here, as in other fields of applied science, there is also good scope for the private investigator. The problems of types (C) and (D) are of similar character. Both involve co-operation between manufacturer, lighting expert and user. But section (D) is reserved for problems of a particularly far-reaching character, and of national importance, where recommendations must be supported by impartial authority of the highest standing.

Research on Photometry and Standards of Light.

Since the Society commenced work in 1909 a great deal of useful work has been done in this field. At the National Physical Laboratory candlepower can be tested with ample precision for all practical purposes. It is true that we still await the ideal primary standard of light. Experiments both in this country and in the United States have been made with a black body maintained at a specified temperature of incandescence, and Prof. J. T. McGregor Morris has reported promising results with an arc formed between three converging carbons, but both devices are in the experimental stage. However, the need for such a standard is not very acutely felt as it has been found possible to maintain the unit of light with sufficient precision by the interchange of calibrated sub-standards between the accredited laboratories of France, Great Britain and the United States. A point of greater practical importance is the maintenance of the "international candlepower," happily agreed upon by these three countries for their common use.

Difficulties in heterochromatic photometry can be diminished by various devices, such as the use of flicker-photometers, tinted standard screens to bring colours into agreement, etc. We now understand much better the nature of these difficulties and the circumstances (*e.g.*, when the colour difference is very marked and the illumination is low) in which they become of importance. Strictly speaking, these effects, arising as they do from the inherent physiological properties of the eye, cannot be entirely avoided, and any method which evades them is

necessarily arbitrary. Inasmuch as we are in practice mainly concerned with illuminants yielding approximately white light it is only rarely that the problem becomes awkward; but in the case of the orange light of the neon lamp and the greenish light of the mercury vapour lamp it is certainly difficult to make any accurate comparison. As it seems likely that in future the application of luminescence may bring about a still greater variety of colours in illuminants for special uses, it would be well to have some agreed basis of testing —even if based on arbitrary assumptions.

In view of the more recent development of interest in systems of "artificial daylight," the reference of the research committee, in 1916, to the need for a standard of "white light" showed foresight. The method of testing such systems, and their comparison with natural light, was dealt with in a valuable paper by Mr. P. R. Ord at the annual meeting of the Society last May. The most scientific mode of testing is doubtless by the aid of the spectrophotometer, but possibly simple and effective tests based on the appearance of selected coloured fabrics might be devised. Some such test is needed, in order to discriminate between "artificial daylight" which approaches close to average natural light in colour and other so-called systems which resemble normal daylight only very approximately. In other words, some method of grading these units, according to their possible uses, in terms of accuracy is needed.

It is now recognised that lighting units are best compared in terms of mean spherical or mean lower hemispherical candlepower. Hence, the integrating sphere, enabling mean spherical candlepower to be determined by a single measurement, is an apparatus of considerable practical value. Recent experiments suggest that a cubical box with whitened interior, a much more simple apparatus to construct, answers sufficiently well for sources having approximately the same polar curve, and the "lumen-comparator" devised by Prof. J. T. McGregor Morris utilises a double box of this kind. The sphere photometer appears to have been found preferable to apparatus using a series of mirrors (*e.g.*, in the Matthews instrument). However, Sahulka has recently substituted a series of matt white surfaces, the diffused light from all of which falls on the photometer, enabling mean spherical candlepower to be obtained with a single measurement. In a later design a continuous surface in the form of a rectangle is substituted. This is a convenient and simple device to construct and may prove useful in technical colleges and laboratories where expense is a consideration.

Illumination photometers are now no longer regarded as laboratory apparatus. They should play a useful part in the training of students in illuminating engineering, and as useful implements of research. But they now also form part of the equipment of the salesman as well as the expert concerned in the planning and carrying out of lighting installations. The advent of simple portable instruments of this type has undoubtedly been one of the most important factors in advancing knowledge of illuminating engineering. In the past absence of suitable measuring instruments prevented our gaining a knowledge of the actual illumination met with in practice. By their use we have learned much regarding the proper distribution of light, the comparative merits of various forms of globes and reflectors, the effect of reflection of light from walls and ceilings, and the conditions of illumination realisable with a certain consumption of gas or electricity.

Yet existing instruments, though extremely useful, are not perfect. Greater simplicity, without undue sacrifice of accuracy, is needed. At present we are dependent on the use of a small glow lamp supplied by a dry cell or accumulator, the decline in voltage of which is a drawback. Most people now agree that instruments should be provided with a volt-meter or ammeter and a rheostat, to enable diminution in voltage to be recognised and corrected. Lead batteries naturally come to grief if neglected, and it seems possible that the new nickel-iron types may prove useful. There seems now to be room for two distinct forms of instruments, one of the highest possible accuracy, complete with all details and yet portable for accurate work, and with

a wide range suitable alike for use in streets, indoor installations, and general research work; second, a more approximate but extremely simple form serving to give a general idea of the order of illumination prevailing. In everyday work we are concerned with a limited number of well-defined steps in illumination. A very simple instrument, for instance, one with a series of slots of graded brightness corresponding to these main steps, which could be read by inspection without a telescope and manipulation to obtain balance, should serve to popularise measurements and find a wide demand.

Much research has been done on photo-electric cells, and it may be that ultimately this will go far to solving the problem of obtaining a very simple photometer for general use. Such cells have been used for such purposes as recording automatically fluctuations in daylight, in "television," and as an element in apparatus for synchronising a kinema picture-film with a record of sound. The photoelectric cell prepared by Dr. Chase in the United States is stated to exhibit sensitiveness throughout the spectrum similar to that of the human eye, and to give a response directly proportional to intensity of light. A reliable cell of this kind should at once prove valuable in the laboratory; for instance, in checking minute variations in standards of light, and other changes too small to be easily verified by ordinary photometric methods. It *may* eventually be applied in a portable instrument which would give a reading on a dial when presented towards a source of light, the instrument being calibrated in the laboratory so that the eye of the user would be relieved of the process of making a photometric balance, which presents difficulties to those unfamiliar with photometry.

Another problem, partly photometric, is the devising of a simple instrument for the measurement of "glare." The effect of glare or dazzle depends on many factors, which will be discussed shortly, but it is accepted that the brightness (candlepower per square inch) of the source is one of the most important items. As a knowledge of brightness also enters into other aspects of lighting, a simple form of instrument to enable this quantity to be quickly and easily determined would be very useful. It may be, however, that this alone would uot suffice and that some tests based on the actual physiological effect of glare may also be needed. There are many other profitable fields for research in photometry, amongst which may be mentioned (A) the testing of absolute coefficients of reflection of materials; (B) the preparation of neutral glasses of standard absorption and surfaces of standard reflecting power, and (C) the devising of large scale "demonstration" photometers (on lines similar to the photometer devised by the I.E.S. Research Committee for testing flares and star-shells) in order to reveal effects of different reflectors, etc., to a large audience.

Daylight Illumination.

A brief reference should be made to one very important development—the measurement of daylight and its application to the prediction of access of natural illumination into buildings. This subject was dealt with very ably and comprehensively in a paper before the Society by Messrs. P. J. and J. M. Waldram last year, and it is also being studied very closely at the National Physical Laboratory by the aid of the special experimental building now completed. This work is based mainly on the "daylight factor" (the relation between the illumination at a specific point within a room and the total unrestricted daylight out of doors). The value of this process in practice has been very fully justified, especially in connection with recent "ancient light" cases. But there still remains a great deal to be done in estimating the influence on the daylight factor of such items as height of window in relation to depth of room, relation of window dimensions to distance between windows, and aspect, time of year and influence of neighbouring buildings and other obstructions.

It has already been pointed out that this field of work affords a specially good opportunity for co-operation between the architect and the lighting expert, in order that the data being accumulated may be put into a convenient practical form. It should also not be forgotten that the light entering buildings, whether

by side windows or skylights, must penetrate the *glass*. It is curious that at present very little information regarding the percentage of light absorbed by various kinds of window glass is available. This percentage is often very much greater than is commonly understood—especially when the glass is only cleaned very occasionally. In cases where it is attempted to frame a minimum "daylight factor," the effect of such absorption needs consideration, and some guidance should be given to manufacturers as to the frequency with which they are expected to clean the window glass—at present referred to only vaguely in existing legislation. Other points of interest are the effect of systems of interior decoration of walls, etc., or enamelled brickwork on the daylight factor, and the utility of light-coloured blinds, both in limiting glare from direct sunlight and in promoting good diffusion of artificial light.

Illuminants and Lighting Appliances.

Progress in lamps and lighting appliances naturally depends mainly on the manufacturer. Discussions before this Society may reveal "wants," or suggest possibilities of improvement. But the working out of the idea will in general be done in the laboratory of a manufacturing firm. It is common knowledge that many of the early advances in illuminants originated in this country, which, for instance, was identified with pioneering work in gas lighting, and the researches of Swan and others on electric lamps. There is no inherent reason why it should not be as much in the front in future as it was in the past. The years following the war have been characterised by progress in detail rather than radical advances, but it is possible that we are now entering on a new era of progress. Hitherto the history of the lighting industry has been marked by sudden steps forward with intervals of steady development in detail. Such periods of quiescence may be devoted to such matters as avoidance of undue variation in design. Differing dimensions of bulbs of electric lamps of similar wattage are highly inconvenient, and this point is receiving attention from makers. Similarly a Committee of the Institution of Gas Engineers is considering incandescent burners. Much remains to be done in connection with illuminating glassware, especially of the heat-resisting and diffusing type. Marked variations in the optical properties of diffusing bowls are not uncommon, and naturally interfere with calculations of illumination.

As regards the efficiency of illuminants, theoretically it should be possible to obtain as much as 25 candlepower per watt from an ideal source yielding white light, and perhaps 50—60 candlepower per watt from an ideal source producing the most efficient yellow-green rays, and no others. There is therefore still ample margin for improvement in the case of electric lamps, and it is probable that in the case of gas lamps the advance in efficiency theoretically obtainable is even greater.

From a scientific standpoint great interest attaches to recent work on the fluorescence of gases, as exemplified in the simple neon lamps recently introduced. This method of producing light is probably still in its infancy, and it is also possible that closer study of the phosphorescence and fluorescence of solid materials may yield not merely valuable information on the nature of processes within the atom giving rise to light, but also solid practical results. There are many fields of work—for instance, in coal mines—where the discovery of a portable self-contained source of light of even moderate intensity, neither consuming electricity not based on combustion, would be of immense value. The present trend of scientific research into electronic processes may prove to have a vital bearing on the problem of efficient light-production, and also on the possibility of "storage of light," illustrated on a small scale by the phosphorescence of calcium sulphide and similar materials.

New methods of producing light may enable us to secure special *colours* in far greater quantity than in the past. It is well known that incandescent illuminants, yielding a continuous spectrum, contain but little of such colours as red and blue. The neon and mercury vapour lamps are respectively rich in these hues. Ultimately we may be able to produce at will

only those colours we desire, instead of being obliged to obtain them by a subtractive method, *i.e.*, by interposing coloured screens which absorb the greater part of the light, transmitting only the small quantity of coloured light we desire.

In lighting theatres, picture palaces, exhibitions, etc., and especially in the design of luminous signs and spectacular devices, colour is already playing a conspicuous part. Technical processes involved in the application of coloured light offer a fascinating field for scientific research. In addition, we have an opening for effort which is not properly speaking "scientific," but depends on the instinct and artistic feeling. In this field the co-operation of the architect and artist is essential.

Another question that is beginning to excite much attention is the effect of light on the mind and body. We have had striking testimony from the medical profession as to the value of light as a curative agent in certain "diseases of darkness" (tuberculosis, rickets, etc.). But in addition the effect of light on the mind cannot be gainsaid. Travellers will confirm the view that people living in perpetual sunshine are affected differently from those in northern latitudes, where there is less sunlight, and in winter the light of the sun is obscured by mist and fog—conditions accentuated by the smoke of cities. It is possible that conditions of natural lighting have also an influence on the conditions of artificial lighting that people demand. Those accustomed to abundant sunshine may not be content with an intensity of artificial light that would seem generous to those habituated to the subdued light of a northern winter.

The effects of coloured light are more obscure; but there is probably good ground for the general impression that red light has a "warm" and stimulating effect while green and blue are "cold" and sedative. The psychological effects of colour, therefore, present another interesting field for joint effort—by the lighting expert and the psychologist.

Statements are also frequently made to the effect that this or the other colour is "restful" to the eyes, or favourable to good visual acuity. Here joint research by the physiologist and lighting expert is needed. From the records of research available it appears at present difficult to draw very definite conclusions, though, owing to the lack of achromatism of the eye it would appear that monochromatic light is favourable to acuteness of vision in certain cases.

There remain the effects of invisible radiation, *i.e.*, infra-red and ultra-violet rays. Of the effect of the heat-rays associated with most artificial illuminants not much is known, though common experience suggests that there is no need for alarmist views as to their possible prejudicial influence, provided illuminants are used in a judicious way and fundamental principles of lighting are complied with. The same applies to the ultra-violet rays, which have been the subject of a considerable amount of research. The ill-effects of incautious exposure of the eyes to intense radiation of this kind are well authenticated. They are illustrated by the inflammation of the eyes that have occurred in arc-welding and in some kinema studios where very powerful unscreened illuminants were used. Even in these cases where sources specially rich in ultra-violet light are used, the danger may be avoided by quite simple precautions—as indicated in the report of the committee working under the Ministry of Health which inquired into lighting conditions in kinema studios. The fact that these matters have been studied pretty completely, and the nature of prejudicial effects is well known and can be guarded against, is of considerable interest to the lighting industry. It enables us to show that there is no ground for alarm as to possible ill-effects on vision of existing illuminants. At the same time it is only right that the possibility of such effects should be studied dispassionately and scientifically, especially as regards new illuminants, rich in some special form of radiation, that may make their appearance in the future.

Another very interesting field for research is the effect of light, both visible and invisible, on inanimate objects. Many special effects of ultra-violet rays have been identified. The most familiar of these is their effect in causing the fading of colours. Sir Sydney Harmer, Director of the Natural History Depart-

ment of the British Museum, in a recent paper before the Royal Society of Arts, has drawn attention to the vital importance of this question in relation to the contents of museums, and it is evident that in the case of priceless collections of great national value the choice of the system of artificial illumination, both for revealing and preserving exhibits, is a subject that well deserves research. On the other hand, as in many other cases, this same quality of promoting chemical change may prove very valuable if scientifically applied, *e.g.*, in such processes as the testing of dyes, the sterilisation of water, and the treatment of diseases of the skin by ultra-violet rays.

All these considerations lead one to plead for a broad view of the uses of new illuminants. They should not be considered merely from the standpoint of "efficiency" in lumens per watt, but with a regard to their other special properties and possible applications.

Research on Glare.

The effect of "dazzle" or glare was dealt with in one of the earliest discussions before the Society The term covers several distinct effects, such as the discomfort of the eye when exposed to excess of light, the diminution in visual acuity owing to bright lights in the field of view, and the effects of sources seen "out of the tail of the eye" or of light directly reflected into the eye by polished material The problem is complicated by the differences between individual eyes, and the state of adaptation of the eye considered. A person emerging from a dark room, or in an unlighted country lane, is dazzled even by a mild brightness. On the other hand bright lights are apt to be much less distressing if the surroundings are also bright. One is therefore led to appreciate the importance of *contrast*. A good illustration is to be found in the kinema screen; most people now agree that vision is more comfortable if there is subdued general illumination in the room whilst the film is being shown, so that the eye is not troubled by the severe contrast between the brightly-lighted screen and the darkened auditorium.

There is a general recognition that much remains to be done from the physiological side in order to devise rules and regulations in regard to glare, as manifested, for example, in factories or motor-car headlights. Research of a fundamental character is formidable, and one could not expect quick results. But it should be undertaken if our measures are to be based on authority and scientific knowledge.

At present our methods are largely empirical. They are based on the common knowledge that direct lights in the direct range of vision are distracting to the eye and inconvenient, that the effect becomes less severe as the sources are raised, so that the angle at which they strike the eye becomes more remote from the horizontal. This is the guiding consideration in the recommendations drafted by the Home Office Departmental Committee on Lighting in Factories and Workshops. It has likewise been assumed that a source so shaded that its brightness is not more than five candles per square inch (about the same as that of the average white sky) is not unduly glaring and may be used in the direct range of view. However, some authorities have urged that we should not be guided *only* by brightness of the source, that the total candlepower is also an important factor. Other factors are distance of source, position above the horizontal, and contrast between the source and the surroundings.

It will be seen, therefore, that the problem is a somewhat complicated one. In the case of lighting installations, thanks to the variety of globes and reflectors available, there should now be no great difficulty in designing conditions substantially free from glare. In the case of motor-car headlights it seems at present scarcely possible to devise an apparatus which will illuminate the road efficiently and yet cause no glare to the eyes of people with dark-adapted eyes on a country road. However, several recent forms of headlights, undoubtedly, go some distance towards the solution of the problem, which is also rendered less acute by well-designed street-lighting.

The Intensity of Illumination Requisite for Various Purposes.

The above problems obviously called for joint effort on the part of several

experts, and the aid of the physiologist is specially desirable. The same applies to the fundamental problem of the values of illumination necessary in practice for different purposes. It may be, as hinted previously, that the standard of lighting demanded is affected to some extent by climatic conditions. This might possibly influence requirements for shop-window and spectacular lighting, where people's views as to what is "bright" are partly governed by their experience during the day. But for working purposes the guiding consideration is the illumination necessary to see what one is doing with ease and perform operations as efficiently as possible.

In practice people strike a balance between what they think they can afford to pay and the benefits they receive from improved illumination. It has often been pointed out that expenditure on lighting forms only a small percentage, sometimes less than 1 per cent. of the wages bill, and that therefore managers of factories and employers can afford to take a broad view. But, an increase very much above what has hitherto been considered good practice requires justification. Hence in order to be on safe and solid ground we need to know, by actual tests, the results and benefits of better illumination. The simplest case is that of reading and writing. There are tests to support the view that at least three foot-candles are necessary in order to read good type on white paper, and that correspondingly higher values are needed if the reflecting power of the paper is low or the type unduly small. But there is room for experiment with a view to determining the effects of "super illuminations." We may find, for instance, that very high illuminations beyond those apparently necessary to make out the letters, result in increased speed of reading, and that similarly in industrial operations more light results in speedier work and less mistakes. There must, presumably, be some economic limit, beyond which increased illumination conveys no proportionate benefit. If, for a few typical processes, this limit could be defined, and if the relation between illumination and ease of working up to this point could be graphically indicated, we should have something definite on which to build in the future.

The amount of work involved in treating all the complex industrial operations in this way is clearly enormous and could only be done with the good will of the industries concerned. It is obviously another case for joint effort.

Practical Lighting Problems.

It is, naturally, impossible to consider all the other factors involved in lighting buildings of various classes. In almost all cases other points, such as the arrangement of the lights, freedom from glare, and inconvenient shadows, etc., are quite as important as sufficient illumination. In street lighting, for instance, avoidance of sudden contrasts in brightness is, perhaps, the most important consideration of all.

Many of these problems, the lighting of streets, various kinds of factories, schools, libraries, shops, picture galleries, public buildings, etc., have been discussed before the Society. These, too, are all cases in which joint effort is needed and work is usually best supervised through the medium of joint committees. Every research of this kind, apart from the actual information it secures, serves as propaganda. New circles of the public are reached and interest in illumination is kindled in the most effective way—by allowing the user to share with the lighting expert the interest of discovery.

Statistical Data on Illumination.

I come now to a form of investigation in which this Society has a very direct interest—the collection of statistical data bearing on lighting. There is, firstly, a great deal of useful information to be got out in regard to the numbers of mantles, lamps, glassware, etc., produced in this country, the comparative public demand for different types—*e.g.*, as regards the most popular sizes of lamps, the choice between gasfilled and vacuum lamps of the same wattage, etc. This form of data is no doubt most easily collected by manufacturers' organisations. Some of the information they may prefer to retain for their own use, but much of it could

probably be made public without any commercial disadvantage.

But there are many other forms of inquiry in which the Illuminating Engineering Society and other bodies, technical and commercial, could share. It would be useful to do what has been done in some American cities, that is, to obtain records of the average consumptions of gas and electricity for lighting in houses of definite classes, so as to see what cities fall behind the general advance, and to trace the increase in the amount of light used, year by year. Similar very instructive data might be obtained in regard to outlay on public lighting in various cities, in relation to population. Records of lighting conditions in public buildings, on railways, etc., year by year, would also prove of great interest. In a few cases data have already been presented before this Society showing the great progress made in recent years. An attempt might also be made to relate expenditure on lighting to other essential expenses such as rent, insurance, heating, etc. Attention has recently been drawn to the fact that the provision of access of daylight into buildings does not "cost nothing," but may in some cases be comparable with expenditure on artificial light. This is a point that should surely receive attention from concerns identified with the supply of gas and electricity—especially in densely crowded cities where space is very valuable and special provision for admission of daylight by light-wells, special arrangements for basements, etc., may be costly.

An exceedingly important form of statistical information is that bearing on the relation between lighting conditions and safety and efficiency of work. The annual number of street-accidents, despite the valuable efforts of the London "Safety First" Council, tends to increase year by year—a result doubtless of the ever-increasing volume of motor-traffic and the congestion of the streets. Records of street-accidents are published annually, but although the classification now adopted is an advance on that formerly used, it is still difficult to trace with precision the relation between street-lighting conditions and accidents occurring by night. One is reluctant to add to the burdens of the authorities who already prepare this useful information; but it might be possible to grant access to the detailed records to a competent representative committee, who would be able to review in detail the causes of accidents amongst which inadequate lighting doubtless plays an important part, and suggest remedies.

Practical information of this kind would be valuable in directing attention to the districts where public lighting is in need of improvement and would pave the way for a comprehensive review of lighting conditions throughout the whole of London, the classification of streets in order of importance and traffic carried, and the corresponding allocation of the requisite illumination to each.

Accidents in factories should be similarly studied. It is understood that the Home Office Factory Department is now attempting to trace the relation between these accidents and lighting conditions in detail, and no doubt supplementary researches will be made by the British Industrial Safety First Association.

The problem of obtaining simultaneous records or work in factories, and the corresponding illumination, with a view to showing how better lighting removes limitations to output is very complex. Authentic results of this kind are very valuable, but need to be made with extreme care and judgment, and usually occupy a considerable time. The first essential is the willing co-operation of the manufacturer and the workers in the factory where the tests are made. In some forms of work a direct improvement in quantity may be looked for, in others it would probably be best to judge by reduction of spoiled work. In every case it is necessary to decide exactly what the indication of better work is to be, and to take precautions against the influence of extraneous factors, other than lighting.

These types of research really demand the trained judgment of the expert on statistical matters. It is probable that such researches would gain very greatly if the co-operation of the Royal Statistical Society could be enlisted.

CONCLUSION—FACILITIES FOR RESEARCH.

Although it has only been possible to deal with a few selected points, enough has been said to show the very wide field for research in illuminating engineering. We now come to the final problem, "How is this research to be carried out?" It has often been debated whether research can be organised. There are many experiments, discoveries and inventions, that spring from the spontaneous efforts of private investigators, others are the product of efforts by those on the staff of manufacturing concerns. Naturally all such independent research is welcomed. The best that the Society can do to encourage it is to be continually drawing attention to illumination and suggesting problems, so that an atmosphere favourable to research on illumination is created, and the minds of experimenters turn naturally to this subject. This it is already doing and hopes to extend its efforts in the future. The preliminary arrangements being made for the issue of a textbook on illumination are useful in this way; the issue of such a textbook would do much to ensure a regular place for illuminating engineering in courses at colleges so that the vast possibilities of experiment are kept before the minds of students.

In other cases the Society might approach Colleges and request them to undertake specific researches. The chief difficulty at present is that the professors are busy men, and that post-graduate students can usually only be allotted for such work if a suitable grant for research is forthcoming. The Society has formed a series of joint committees to conduct research into many urgent problems arising from discussions, and in several cases valuable reports have been issued, and in others valuable preliminary work has been done. But it has usually been found that members of such committee, though generous in giving their time for discussion of the programme and supervision, could not themselves afford time for the detailed experiments necessary to carry the work to fruition. A typical case is afforded by the investigation on railway lighting. Useful preparatory work has been done and some data collected. But in order to deal with this matter expeditiously it would be necessary to engage a man specially to travel about the railways and make tests.

Whilst many researches such as improvements in lamps and instruments, etc., may be assigned to individuals, there are many kinds of wide problems, affecting large sections of the community, which demand joint effort and a supervising committee. The work so far carried out in approaching outside bodies and organisations and enlisting their sympathetic aid, should be valuable in the future. It has given us a nucleus of specialists in all kinds of subjects willing to join in the initiation of experiments. In the committee appointed by the Department of Scientific and Industrial Research recently we have also a very valuable medium for research. But in every case the limitation imposed by the Society having no fund for research is felt, and in these days it is impossible to conduct research on a large scale by voluntary effort alone.

Comparisons are often made between the research made in the United States and this country. It is overlooked that in America there are well-equipped laboratories, supported by manufacturing concerns, with a staff of workers engaged solely in carrying out experiments on illumination. In England those interested in illuminating engineering have other occupations, and in the circumstances one can only marvel that so much voluntary effort has been devoted to research of a kind that promises no pecuniary return.

The inference is that in order to push its programme to completion the Society must in future possess a fund for research, to enable them to initiate and supervise experiments and allot workers to specific problems. It is to be hoped that this need will receive recognition from bodies identified with the lighting industry, which would benefit directly from the results of these independent investigations. There is nothing in the way of research carried out in other countries that could not be done equally well in Great Britain. We have a programme of researches, we have assembled experts able to initiate them, all we lack is the necessary facilities and support to go "full steam ahead."

DISCUSSION.

Lt.-Col. K. EDGCUMBE said that the author was to be congratulated on presenting a highly interesting paper in a condensed form; it was no light task to make a résumé of a paper, which itself was a comprehensive summary of possibilities in research.

He agreed that lighting units were best compared in terms of mean spherical or mean lower hemispherical candlepower, and the integrating sphere, which enabled this value to be obtained by a single measurement, was a most useful piece of apparatus. Simplicity should be the aim in such apparatus. The use of a rectangular box deserved further study; information on methods of construction and on the precautions necessary to obtain reasonable accuracy would be welcome. One point of importance was the selection of the material for the inner diffusing coating; unless this was carefully chosen multiple reflections might give the light a decidedly yellow tint.

Mr. Dow had emphasised the need for simplicity in the design of photometers, and suggested the use of a series of slots of graded brightness so as to eliminate the manipulation to obtain balance. He agreed that the avoidance of a telescope was desirable, but the elimination of the process of balancing was of less importance. As regards the limits of accuracy in photometry he thought that under the very best conditions the margin of error might be limited to 1 per cent., but in working practice an accuracy within 4 per cent. was about as much as could be expected. The author's reference to the possibility of "storage of light" opened up interesting future possibilities, and it might be that eventually the illuminating engineer would in this way have a new and valuable weapon at his command.

In conclusion, Major Edgcumbe emphasised the international aspects of illuminating engineering and expressed the hope that this country would be well represented in this field.

Mr. J. W. T. WALSH, referring to a device described by the author for obtaining mean spherical candlepower by the aggregate effect of a series of diffusing surfaces, remarked that surfaces of this kind required careful study. He had found that errors of the order of 20 or 30 per cent. might arise when so-called diffusing surfaces received light obliquely. As regards the photo-electric cell, whilst it was useful for certain purposes, there was a great deal to be done before a photometer on the lines suggested could be relied upon. All such cells examined by him had, in comparison with the eye, curves of very low and variable sensitiveness on which too much reliance should not be placed. He had also found that even photo-electric cells specially constructed with a view to obtaining identical properties behaved very differently in practice.

Mr. W. R. RAWLINGS fully endorsed the opportunities for research by the Society. The manufacturer was necessarily occupied with the business of production and could only devote a limited amount of attention to investigations, even those likely to have a commercial value. There were many problems involving scientific aspects of lighting which required joint effort. Co-ordination, as the author had remarked, was essential in order to formulate proper standards of illumination, and such work should be entrusted to the Society which, in co-operation with other bodies, could obtain figures which would be accepted as unbiassed and reliable. There was obviously a great deal to be done in improving the lighting of the streets of London, and especially in connection with illuminated signs, and he hoped that the London "Safety First" Association would join with the Society in dealing with this problem. The fundamental problems of glare, and the degree of illumination necessary for various processes, as the author had remarked, also needed further study.

Mr. P. J. WALDRAM remarked that there were some manufacturers who took a wide view of research and had spent a considerable amount of money in this way. After all those who first gained the knowledge gathered the first financial fruits of their general en-

deavours; many manufacturers did not believe in the policy of bottling up discovery, for it was only by the general appreciation of such discoveries that their own interests could be served.

The Society must make every effort towards advancement, for it was an undoubted fact others were only ready to help those who first helped themselves. The published results of work undertaken by a Society which had no axe to grind were of the greatest value and a few words from such a body carried more weight than statements made by an individual firm. Therefore the Society should do its utmost to carry through research and to resume and, if possible, surpass the efforts made in this direction before the war.

Mr. ARTHUR CUNNINGTON said he was interested in Mr. Dow's reference to the need for simple measurements of brightness and in that connection he wished to raise again the question (previously referred to in 1917) of the basis on which intrinsic brightness should be calculated. Most experimenters had assumed that the *projected area* (of, say, an electric lamp filament) was the correct basis. When this subject was raised on a former occasion Mr. Trotter had agreed that it was not correct to assume the width of a lamp filament when cold as the area from which light was emitted when the lamp was burning, and he pointed out that the apparent width of the filament might easily be ten times its actual width, in which case the figure for intrinsic brightness given by the ordinary method of calculation would be far from accurate. Probably the method adopted in the case of gas mantles of assuming the whole area, including the space between the fibres, to be the source of light would give results of a more practical value, but in the case of an electric lamp the assumption of the virtual area of the light source would be a difficult matter. It appeared to be very desirable that further research should be carried out in this direction so that some reasonable basis of comparison could be arrived at.

Mr. Cunnington also referred to the work of Messrs. W. Sugg & Co. in developing a gas lamp with suitable reflector for giving even distribution on a horizontal plane, and which would at the same time be suitable for outdoor use. It was an indication of the desire of manufacturers to co-operate in meeting special requirements of illuminating engineers that a firm of this kind was prepared to undertake an amount of experimental work in order to arrive at a suitable fitting.

Mr. A. BLOK said that Mr. Dow had enumerated a great variety of subjects for research. The Society was concerned with two large industries and a host of minor activities, and any science on which depended such great commercial interests was well worthy of study. There were many problems confronting the gas and electrical industries which the Society should help to solve. But the researches of manufacturers, which in many cases had large organisations to cope with the work, should also be welcomed, for there were many problems which could best be dealt with by them. Research could not be forced, but it could be guided and the Society could do useful work in this way.

Mr. LEON GASTER referred to the appointment of a Committee on Illumination by the Department for Scientific and Industrial Research. This commitee was of a representative character and contained some members who were also members of the Society, and could therefore suggest problems arising out of its discussions which appeared to deserve attention. It was necessary to select, from the great variety of problems, those which seemed most urgent and most likely to yield results in the immediate future; the discussion of this paper should prove useful in this respect. In this discussion it had been generally recognised that there were many problems which could only be dealt with by an impartial and fully representative body with no axe to grind. A good instance of such researches was afforded by the work of the Joint Committee on Eyestrain in Cinemas, on which eminent oculists, representatives of the cinema industry and other experts served, and which was so constituted that its conclusions could be accepted as authoritative.

It was only natural that this country should have its own ideas on the subject of illumination, and in future, when the international treatment of these problems would be rapidly developing, it should take a proper share in the work and maintain its position in the field of illuminating engineering.

The CHAIRMAN (Mr. D. R. Wilson), in proposing a vote of thanks to the author, expressed his interest in the work of the Committee appointed by the Department for Scientific and Industrial Research, and referred to the complex problems that had arisen in connection with industrial lighting. In all such investigations the practical application had to be steadily kept in mind; otherwise, if one concentrated on what might be termed *ad hoc* research, one was apt to accumulate masses of data and then find a difficulty in making practical use of them.

Mr. J. S. DOW: In reply, I should like to thank the various speakers for the reception of the paper, and am glad to note the general feeling that there are some forms of research which can only be properly underaken by an impartial and representative body such as the Illuminating Engineering Society. But it should of course be recognised, as indicated in the paper, that manufacturers with their special facilities for experiment can do a great deal of valuable work; to their efforts we owe the substantial advances that have been made in illuminants and lighting appliances during recent years. Most of the other comments dealt with photometry. I agree generally with the remarks of Lt.-Col. Edgcumbe, though, as regards the accuracy of illumination-photometers, I think that in many cases an accuracy within 10 per cent. is about the best obtainable; this, however, suffices for most commercial work.

Mr. Walsh's remarks on diffusing surfaces were interesting, and no doubt this point would need careful consideration in the case of apparatus of the type described. I agree that, as Mr. Cunnington suggested, greater precision is needed in defining the brightness of sources. As regards the use of photometric cells there are at present evident difficulties, but considerable progress in this field appears to have been made abroad and their possible ultimate application in the illumination-photometer should not be lost sight of.

SOME NOTES ON TRACTION LIGHTING BY ELECTRICITY.

(Proceedings at the meeting of the Society, held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 8 p.m., on Tuesday, February 19th, 1924.)

A MEETING of the Society was held at the House of the Royal Society of Arts on Tuesday, February 19th, Mr. L. GASTER presiding.

The HON. SECRETARY read out the names of applicants for membership announced at the last meeting, who were now formally declared members of the Society.

Mr. J. F. CAINE then opened the discussion by reading the paper by himself and Mr. E. A. MARX, Junr., on **"Some Notes on Traction Lighting by Electricity."**

In the subsequent discussion Mr. A. CUNNINGTON (L. and S.W. Section of the Southern Railway), Mr. GRAFF BAKER (Underground Railways), Mr. G. CAMPBELL, Mr. L. E. BUCKELL, Mr. H. J. TROUGHTON, Mr. MOORE and Mr. L. GASTER took part. Mr. Marx briefly replied to some of the points raised in the discussion.

After a vote of thanks to the authors it was announced that the next meeting would take place at 8 p.m., on **Friday, March 21st,** when there would be a discussion on **"The Use of Light for Modern Advertising."**

SOME NOTES ON TRACTION LIGHTING BY ELECTRICITY.

By J. F. CAINE and E. A. MARX, Jr.

Abstract of Introduction to a discussion at the meeting of the Illuminating Engineering Society, held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 8 p.m., on Tuesday, Feb. 19th, 1924.)

ON several occasions papers have been read before the Society dealing with the question of railway lighting, notably by Mr. Haydn T. Harrison, in 1911, and by Mr. A. Cunnington, in 1919; while in 1914 a paper on the *Lighting of Railway Carriages and other Public Vehicles* was read by Mr. Kilburn Scott.

A considerable amount of information is thus available, but in some cases the degree of illumination and conditions of lighting have not yet been fully determined. It is, therefore, hoped that these notes will furnish a basis for further discussion.

Electricity is now very widely employed for the lighting of buses, as well as tramcars and railway-coaches. Great advances have been made during recent years. There was a time when the oil lamp, hanging in the middle of a compartment, was considered the height of luxury, though passengers not infrequently obtained supplementary lighting by candles. But in these days it is not considered enough merely to provide enough light to enable one to see fellow-passengers; a standard of illumination sufficient for reading, writing and knitting is now demanded.

Lamps.

One of the first difficulties to be overcome in the lighting of all forms of vehicles is that of *vibration*. There is invariably a good deal of high frequency vibration in all directions, but chiefly vertically and horizontally along the direction of motion. There may also be jerks and shocks administered horizontally, but across the direction of motion. Railway coaches and trams tend to oscillate about a vertical axis through their centre. There are few jerks and jars in a vertical direction in vehicles running in rails, except occasionally in passing over points, and practically none in the direction of motion, except in the case of suburban and tube railways where exceptionally high acceleration and retardation are necessary. In the case of motor-vehicles running on roads, vibration, jerks and jars of considerable magnitude may occur in every direction.

Lamps for use in railway carriages must be designed to withstand high frequency vibrations and shocks of the variety mentioned above. Many of the leading manufacturers have found that the spiralised filament, mounted in a "castellated" form, is most satisfactory. In this type of lamp there are only short lengths between supports and two vertical sections to every horizontal one. This reduces the strain considerably. Similarly up-and-down winding of the standard vacuum type of lamp gives ability to resist transverse jars. Shock along the length of the filament tends to decrease tension momentarily on the support towards which the shock travels; and to increase tension on the other support, and vice versa on the rebound. It is this increased tension that strains and weakens the wire. On the other hand a shock *across* a length of filament makes it vibrate like a bow-string, only slightly altering the tension on the supports. In the case of spiralised filaments the spiral acts like a spring and thus resists shock to an extent which a plain wire cannot do. In addition the glass support in a traction lamp is made as short as possible to reduce strain. The combination of these various precautions enables the modern lamp to withstand a considerable amount of vibration.

There is one other point that deserves attention. Sometimes the lamp-holder (especially a bayonet cap type) is a trifle large, and if the supporting springs are weak the lamp is not held sufficiently rigid and tends to "wobble." This

naturally increases the strain and such holders should be replaced by one that holds the lamp firmly.

Voltage.

There is, unfortunately, no one standard voltage for lighting trains. In some cases the current is obtained from axle-driven generators through a floating battery to maintain constancy and permit lamps to be kept alight for a fair period whilst the train is stationary. In such cases 20-30 volts, maintained with little variation, is usual.

In the case of electric trains and trams, where track supply is available, several lamps are usually run in series or, if the supply is a.c., a transformer may be applied (though this course is not usual). For suburban railways and tramways between 500 and 600 volts is usual, four or five lamps being run in series, thus taking 100-125 volts each. Direct current is commonly employed. An exception is provided by the Brighton section of the Southern Railways where 6,600 volts single phase a.c. is used, the pressure being transformed down to 370 volts on the train, and the lighting worked directly off this.

In other countries d.c. pressures as high as 1,500 volts are not uncommon. In discussions regarding main line electrification in this country the possibility of using this pressure has been mentioned, and this step would present the lighting expert with new problems in train lighting.

It must be remembered that low voltage lamps are distinctly more efficient than those made for higher pressures. Thus a 110 volt 60 watt gasfilled lamp yields about 700 lumens, a similar lamp for 250 volts only 570 lumens. This is a consideration in favour of low voltage lamps. An important question on electric railways and tramways is pressure drop and variation. When a train is accelerating there is naturally a momentary high current and the pressure at that point drops considerably. On some tramway systems this may occasion a fall from 550 volts to 350 volts, and on the Italian railways it is the practice to allow for a possible drop of 35 per cent. The candlepower (c.p.) and the voltage (v.) of an incandescent lamp are connected by the relation :—$c.p. = k.\ v.^{4\cdot57}$, k. being a constant. Hence a fall of 5 per cent. in voltage means a drop of 21·5 per cent. in candlepower, and 35 per cent. fall in voltage a diminution in candlepower of 86 per cent. It is evident, therefore, that to the lighting expert the variation in voltage on railways is of considerable moment.

For road vehicles a low voltage is essential, current being supplied either from accumulators or from a small dynamo run from the engine and charging a battery. Excessive shock and vibration necessitates a filament with a minimum length between supports. As indicated above the higher current allows of greater cross section of wire which gives it more strength. In cases where current is generated on the vehicle care must be taken that the voltage does not become too high, *e.g.*, when the car is running very fast with the battery well charged. Excess voltage naturally shortens the life of a lamp considerably.

Railway Carriage Lighting.

Train lighting may be divided into two types, according to whether one is dealing with a saloon coach, as used on the underground railways, or the compartment coach.

In either case the problem resolves itself into avoidance of glare in the eyes of passengers and proper distribution of light. It is customary at present to use bare lamps in most cases, or lamps in some shallow fancy shade. It must be admitted that the glare from a row of unshaded filaments is objectionable, especially to persons standing up so that they fall within the direct line of vision. The methods of shading adopted in a few of the most recent installations give more pleasing results. Recent work in this field has been largely experimental. Ordinary lighting fittings are unsuitable owing to the limited headroom and other reasons. At the present time there is no device that can be regarded as a standard fitting for lighting carriages. Another drawback to some existing methods is that, owing to the positions of the lights, much of the rays pass out through the glass of the windows, instead of falling on the papers of passengers.

In compartments the corners require to be lighted just as well as any other part since, in fact, they are the parts most used; a corner seat being always looked upon as the best. In corridors it is a long narrow strip that is to be illuminated and units giving circular illumination are wasting a large proportion of their light.

Coach-lighting may be dealt with in various ways. The coach may be divided up into a number of small squares and concentrating fittings employed as in Fig. 1. Another method is to divide the coach into larger squares as in Fig. 2. This in effect is similar to the treatment of compartment coaches but is not so suitable for existing coaches as the last method owing to the alteration of points, and the need for higher wattage lamps. Bad shadows may also be produced.

A third method is shown in Fig. 3 where each fitting is at an angle so as to throw the light on to the opposite side of the carriage. This provides greater horizontal and vertical illumination, but it must be so designed that light is not directed into the eyes of a person sitting at the side and facing inwards. There is also danger that people standing down the middle of the coach may interfere with the light. Hence the method is not suitable for underground railways where there are crowds travelling—nor always suitable for dining cars where the seats run across, since shadows are liable to be produced.

In dining cars and similar saloon type coaches the method of putting brackets or table standards over each table is often adopted. This is effective from the reader's standpoint but is apt to leave the gangways in shadow. It is unsatisfactory to have only the tables strongly illuminated, giving excessive contrast with the relatively dark walls and ceiling. The other extreme, an unduly bright ceiling, should also be avoided, and the ceiling should be painted dead white (or preferably cream or fawn colour) without shine which gives rise to troublesome reflections of lamp filaments. Another method utilises the ordinary train lighting lamps in trough or panel reflectors (Fig. 4). Twenty-three of these trough fittings, 2 ft. 9 ins. long with a cylindrical opal glass front were installed in two rows in a coach with spaces between the fittings. Two 32 volt 20 watt lamps are allotted to each fitting, *i.e.*, 920 watts to the coach. With this arrangement an even illumination of five to six foot-candles was obtained. There were eleven fittings down each side of the coach with dummy fittings in between and one fitting at one end, the other being occupied by the driver's compartment. The reflectors are 4 inches deep and the two lamps are evenly spaced and burn horizontally. Three-sided aluminium trough reflector directs the light through the flashed opal glass, which diffuses the light evenly. Looking down the coach one receives the impression of a line of light on each side. The coach appears brightly lighted without glare and the general appearance is pleasing.

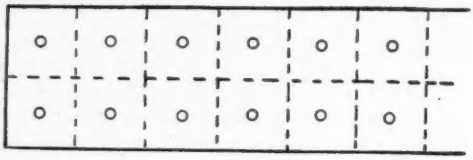
At this point the question may be raised: "What is the desirable standard of illumination in railway carriages and public vehicles?" At present values in most cases range from one to three foot-candles, but the latter figure is probably not often attained. It will be agreed that the illumination provided should suffice for reading and writing and perhaps also for knitting and sewing; the fact that there is considerable vibration makes reading and similar work more trying to the eyes, and hence calls for a somewhat higher illumination than is usually considered desirable for such purposes. Many people complain of fatigue after a railway journey and this may often be due to the effort of reading a vibrating book by insufficient light.

The recommended practice of libraries and schools, that is to say for reading and writing, is 5 foot-candles and in trains and trams where reading is done, the light should not be less than this, especially as it is under more trying conditions.

Taking all these factors into consideration it may be suggested that at least five foot-candles is desirable. Moreover, a well-lighted vehicle has a more cheerful appearance and serves to attract the public.

Drivers' Compartments.

In the actual control compartment it is probably best that there should be *no*



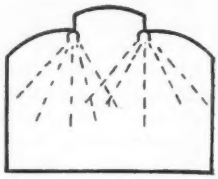
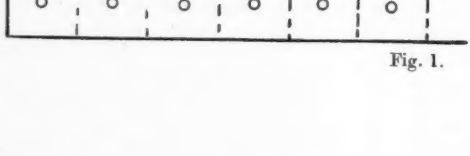


Fig. 1.



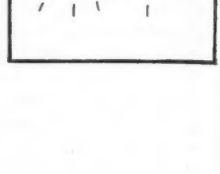


Fig. 2.

Fig. 3.

Fig. 4.

illumination. This may seem to be a somewhat startling conclusion but has justification. A driver looking out of an artificially lighted compartment into the surrounding darkness would find difficulty in distinguishing signals, etc.; moreover, his vision would be apt to be interfered with by reflections of bright objects in the window, or by illuminated dust on the glass, forming a luminous haze. It is common experience that in driving a car at night it becomes difficult to see objects ahead with lights on near the driver or even a light on a dashboard, while persons inside a lighted car find it still more difficult to distinguish things outside. Accordingly, while lighting fittings may be installed for the driver's convenience when the train is at a standstill they should be turned out when the train is in motion. Possibly some local illumination may be necessary to reveal the dials of instruments but in this case the source should be completely concealed from view and the illumination should not be high, perferably not more than 0·5 foot-candle. It must be remembered that when one is looking out into darkness even a moderate brightness, seen within 60 degrees of the direct line of vision, may cause inconvenience. These remarks apply equally to drivers of trams and buses, especially when they have a glass screen in front of them. [The conditions in fact are similar to those discussed by Mr. Cunnington in his paper before the Society in reference to the lighting of signal boxes.]

Trams and Buses.

The difficulties considered in connection with the lighting of railway carriages are accentuated in trams owing to the limited headroom. It is seldom that more than 6 in. can be spared for the fitting—a small space when one considers that the lamps used in trams are usually 4⅜ in. long. There is, however, room for fittings of a distributing type which will also shield the filaments effectually. The anti-glare fittings used on the L.C.C. trams mark a distinct improvement. There is, however, still a considerable amount of light which strays out through the windows and is thus wasted. Trough reflectors placed above the windows and with an angle of dispersion sufficient to keep the light directed on to the seats might improve these conditions. A white ceiling is desirable, both in order to diffuse the light and to make the interior of the car appear cheerful by day and night. One circumstance that may interfere with the idea of distributing light mainly on the seats is the use of the sides of the roof and tops of windows for advertisements—a practice adopted in many buses and trams, and also in some suburban trains. Presumably those who take space for such advertisements would expect them to be adequately illuminated. Lamps should be so placed as to avoid the casting of a shadow of the handrail on the ceiling.

The lighting of the top deck of open trams and buses varies so much according to the different type of vehicles that no hard and fast rule can be laid down, but it may be said that the practice of using bare lamps is bad. Reflectors could always be designed to control the lights.

Headlights.

The design of headlights is a special subject, which can only be touched on briefly in this paper. In some countries abroad, where the line is open and exposed and often runs through wild country, powerful headlights for locomotives are necessary in order to enable the driver to see the track ahead. In this country, where lines are adequately protected, there is little need for very bright headlights, the glare from which is apt to prove distracting to the eyes of drivers of approaching trains. Lamps, therefore, serve mainly as signals. Trams and buses in cities do not need powerful headlights and signal lights are all that is necessary, but when they are running on country routes they are often needed to light up the road; but they should be dimmed on entering a town, otherwise the beam would be objectionable to other traffic.

RAILWAY LIGHTING.

Platform Lighting.

The subject of railway lighting, as distinct from the lighting of carriages and vehicles, has been much discussed and was dealt with in detail in Mr.

Cunnington's paper. But the wide variations in lighting conditions still met with show the need for improvement and standardisation. For example, at leading London termini values for platform lighting varying from 0·04 to 4·7 foot-candles have been found.

Stations have been customarily classed under three headings: (1) Terminal Stations; (2) Important Junctions; and (3) Suburban and Wayside Stations; and different standards proposed for each. It would seem, however, that requirements for (1) and (2) are much the same. Sufficient light is needed to enable passengers and staff to see their way about, avoid luggage or obstructions, and read notices and indications of destinations of trains. Carriage steps and the edge of the platform should show up clearly in order to aid passengers in alighting. The writers would suggest a minimum of 2 foot-candles in these cases and 1·0 foot-candles for class (3). Higher illuminations already exist at some stations, and the consumption of energy to attain these standards should only be about 0·3 and 0·15 watts per sq. ft. respectively, assuming a utilisation efficiency of 50 per cent. (rather below the average). With modern scientifically designed reflectors it should be possible to approach a diversity coefficient of 1. The value recommended for wayside stations is doubtless higher than is at present provided in many instances, but in such cases economies might be made by only turning on the full lighting when a train is actually due. "Beacon lighting," which usually only afford illuminations between 0·005 and 0·06 foot-candles, is surely inadequate. Accidents caused by passengers alighting when the train has not reached a station platform are occasionally reported; such a mishap would not occur if people were accustomed only to well-lighted stations. Another point of consequence is the *contrast* between the platform surface and the permanent way, which is aided by the practice of whitewashing the edge of the platform.

There are also various places where special lighting is necessary; for instance, at barriers (3 foot-candles), for customs examination (8 foot-candles), and at windows in booking halls (5 foot-candles). Customs examinations in particular require a high illumination in order that the work may be done quickly and efficiently. Trunks and cases have to be minutely examined, and good illumination doubtless increases the speed with which this can be done. Time-tables are best illuminated by light transmitted from behind.

Station Names.

Much has been said regarding methods of rendering station names more distinguishable, *e.g.*, from adjacent advertisements. A vertical pillar of, say, four red and white stripes each 2 ins. wide on each side of the board would separate it from the rest of the colours. Then if the board were of some dazzle pattern, say, red and yellow check, the name, written in big white letters across it, would stand out well. It should be remembered that a white word written on a coloured ground stand out better than the contrary, a coloured word written on white ground.

Then at night why not illuminate the sign in some colour, say blue, for example? Only the lamp itself must not be seen or it will seriously impair the visibility of the sign. The name plate should be illuminated to a high intensity.

Other Problems.

The lighting of yards, goods sheds, etc., presents many technical problems, and the value of good illumination in ensuring safety and speed of work is now receiving recognition. In such circumstances glare is specially objectionable and deep-skirted reflectors completely screening the filament from the eyes of workers should be used. In many such places there are desks which receive local lighting, which should not exceed 3 foot-candles, so as to prevent the trying effect on the eyes of clerks of looking continually from the brightly illuminated desk to darker surroundings.

Similarly in a signal box the lighting should not exceed 2 foot-candles except on a desk where it might be increased to 3 foot-candles. Otherwise the workers' eyes are subjected to the strain of constantly adjusting from one extreme to the other.

CONCLUSION.

The chief points that arise in this paper may be briefly summarised as follows :—

(1) The need for more general use of scientifically designed lighting units in vehicles to replace bare lamps, ensure better illumination, and prevent wastage of light.

(2) No light in drivers' compartments, and only subdued illumination in all cases where workers have to watch dark spaces outside ; glare should be restricted and abolished wherever possible.

(3) Station platforms should be evenly illuminated at a fairly high intensity and country stations should be illuminated and the present system of beacon lighting given up.

In addition it may be urged that the complete lighting of a railway or a system of trams and buses should be under the control of one expert, and not split up between various departments. Further, lighting conditions should be considered at an early stage when improvements or extensions are undertaken, as it is only in these circumstances that the best results can be economically obtained.

DISCUSSION.

Mr. A. CUNNINGTON (L. and S.W. Rly.) said that the whole paper was interesting to him because the lighting of vehicles was allied to railway lighting, and much could be learned from the study of lighting for other forms of transport. Progress from present conditions to ideals must naturally be gradual. He wished to associate himself with the general conditions laid down by the authors, but he thought that the standards laid down for Class 3 stations were impracticable. In suggesting 1 foot-candle minimum for such stations, the authors perhaps did not fully appreciate what this involved. There were thousands of stations of this type, on which the platforms were practically uncovered and lighting had to be from ordinary lamp-posts, 50 to 60 ft. apart. A minimum of 1 foot-candle in such circumstances would mean a maximum of 8 or 10. Where was the money coming from to pay for this increase ? In such small wayside stations the problem resembled street-lighting, and in fixing the amount of light necessary and attainable with reasonable expenditure one should bear in mind the values usual in public lighting.

Similarly in regard to illuminated name-boards for stations, he was entirely in favour of the principle. But it was necessary to consider the cost of this extra lighting. An illumination of 0·2 to 0·3 foot-candles was at present quite sufficient to enable the name to stand out against the much darker background. To provide ten times this illumination would mean spending perhaps £5,000 where £500 would otherwise be sufficient, and it was naturally difficult to induce railway directors to make such expenditure without good reason. Very likely 10 foot-candles would not be excessive in the case of competitive advertisemens in a brilliantly lighted neighbourhood such as Piccadilly Circus. But on railway stations conditions were quite different. Name-boards were usually put near the end of the platform, where there was relatively little light, and it was now suggested that they should be placed even beyond the platform, so as to allow passengers as much time as possible to prepare to alight. In such circumstances a very low illumination would answer requirements.

Mr. Cunnington added that in pointing out these aspects he did not mean to approve a parsimonious attitude towards the use of light on railways. On the contrary he quite agreed that there was much room for improvement. But one's object must be to get the very best value from the light one could afford to provide, so that one could devote attention to places where higher illuminations were clearly desirable. Thus, whilst he had tried to show that the illuminations recommended by the authors could not readily be attained in Class 3 stations, he would like to associate himself heartily with the authors in their suggested minimum for important stations. As to the classification of termini stations and their discrimination from important

junctions, it should be remembered that a terminal station was a place where people congregated. The whole station was designed on a different plan from that of the Class 2 stations, and that was a reason for a higher illumination, though admittedly the kind of work done in the two classes of stations was broadly similar.

In conclusion, Mr. Cunnington exhibited two recent examples of gas-lamps fitted with name plates for stations in such a manner as to illuminate the latter, and render them clearly distinguishable.

Mr. GRAFF BAKER (Underground Railways), referring to the statement in the paper regarding the fitting of lamps in holders, said that he thought the screw lamp holder much the best for railway work. In regard to the use of shades in carriages, the cost of making alterations on a larger scale must be considered, and in many cases the small space available rendered the fitting of shades a difficult matter. The authors had recommended a matt finish for ceilings in coaches, but a finish of this kind inevitably got more dirty than a glossy one, so that in practice its reflecting power was usually less. In practice it was not usually possible to allow for the repainting of ceilings more than once a year. Similarly in the case of lamps, one had to consider conditions in actual practice, *i.e.*, when a lamp had burned for a considerable period and lost much of its original candlepower.

He had been much interested in the trough system of lighting described in the paper. Something similar had been tried on the Underground Railways but had required a considerably increased number of lamps to get the same illumination. One important factor on electric railways was the attraction of dust by fittings, due to the high potential. Thus it was difficult to make troughs airtight, and it had been found very difficult to keep bowl fittings in decent condition. Hence they had come to the conclusion that shades must have apertures at the bottom, and must not be able to collect dust inside.

In view of the low cost of current on the underground railways the chief item was the cost of the lamp. Hence they had found it economical to get lives of 1,400-1,500 hours by using lamps of low efficiency. The standard of lighting suggested by the authors, if it could be maintained throughout the life of the lamp, would be satisfactory. In regard to elimination of glare, he agreed that filaments should be screened so far as possible, but the general appearance of the lighting units must be considered and it was not advisable to adopt any anti-glare device of an unsightly nature.

Mr. G. CAMPBELL agreed with Mr. Graff Baker regarding the importance of appearance, especially in the case of terminal stations. He mentioned a station on the Great Northern Railway as being particularly badly lighted, especially on the suburban side. The case of wayside stations, where there were perhaps three travellers a day, was not urgent, but he contended that some of the terminal stations in London were badly lighted, and that, even in the case of those where the illumination was relatively high, the appearance of the lighting fittings had not received the attention it deserved. A terminal station was a waiting place and a meeting place. Surely a little of the money at the disposal of the great railway corporations could be spent on improvements in lighting.

Long-distance travelling was, of course, quite a different thing from local electric traction. As regards the anti-glare devices used on the L.C.C. tramways, he agreed that the appearance was not good, but perhaps it was better for the tired straphanger to be looking at a shaded light, even if unsightly, than a brilliant one. With the development of electricity for traction work the cost of current should be diminished, and appliances were also getting cheaper. We might expect great improvement in the future, but meantime one could hardly visit any system without being struck by the need for advances in lighting, in carriages and in most other departments.

Mr. L. E. BUCKELL said it was encouraging to hear engineers on railways referring to the importance of lighting, but in travelling on any system one realised how much room there was for improve-

ment. Most people living in big cities spent a large part of their time in trains. If, as had been stated, the cost of current on electric railways was trifling, surely this justified more generous provision of light, and expenditure on efficient apparatus and renewals. There was a vast difference between the low-voltage lighting of steam-driven trains and the high-voltage lighting on those electrically driven. Much trouble had been caused by lack of appreciation of what series lamps really involved. Since this had been realised much of the difficulty in providing a suitable lamp for electric traction had vanished. One reason why some railway engineers still believed in low-efficiency lamps was doubtless a loss of life—due to the fact that the lamps were unsuitable for series burning. The gasfilled lamp was the ideal one for train lighting, but naturally the filament needed screening. But in lamps with diffusing bulbs the glare-difficulty was completely overcome.

The variations in voltage on electric railways had a material influence on the choice of efficiency of lamps. If the lamp was underrun then, at certain periods, the light became so dull that one could not read at all. He would like to ask if the question of using generating sets to furnish current at 24 volts on electric trains had ever been considered. This would seem to avoid the difficulties arising from variation in voltage.

Mr. H. J. TROUGHTON (M.E.T.) said that praise was due to manufacturers for the advances made in lamps during the last few years. In the experience of his Company the life of lamps had been very materially increased, and was still improving. Reference had been made to high acceleration and deceleration affecting the life of lamps. Such acceleration and decelaration was probably greatest in the case of tramcars with magnetic brakes; but in his experience the use of these brakes did not seem to affect the life of lamps appreciably.

In regard to ceilings he agreed with Mr. Graff Baker that cleanliness was the most important factor. On the cars worked by his Company they did not have drivers' compartments, but they had obtained sanction to run a car with a vestibule. In this case they had found it necessary to have a blind to pull down behind the driver so as to get rid of glare from lights reflected in the glass window. Experiments had been made with headlights, but there was some difficulty in arranging for the switching off of these in the better lighted thoroughfares.

Mr. MOORE, who said that he was associated with the lighting of surface railways, expressed his agreement with Mr. Cunnington's remarks on the lighting of third-class stations. However desirable it might be to improve the lighting in such cases, the practical possibilities were greatly limited by financial considerations. In regard to the illumination of station name plates he agreed that modern illuminants demanded new methods. In the old days, when sources were much less bright, one could arrange for the plate to be near the lamp. But with the much brighter sources of to-day the glare with such methods would prevent the names being clearly seen.

The CHAIRMAN (Mr. L. Gaster) briefly recalled the conditions during the war when it might be said that the underground was the only railway on which one could read a newspaper in comfort. Some criticism had been levelled at the methods of to-day, and, seeing that they obtained electrical energy so cheaply, he had no doubt that the Underground Railways would be ready to make improvements, if the claim was justified. No doubt, as the authors had remarked, the vibration on railways was one reason why people found reading difficult and complained of the light. Apart from this there was a general tendency towards higher values. The older authorities considered 2 foot-candles sufficient for reading in schools. Then the standard was raised to 3, and in the United States, 5 foot-candles, and he observed that the Post Office Authorities in that country had recently recommended 8. On buses the provision of a high and uniform reading illumination was more difficult, but here

also there had been substantial improvements.

He entirely endorsed the view that lighting problems on a railway or public vehicle system, should be dealt with by a special expert, who would naturally co-operate with the traffic and other departments concerned. In the same way it was now recognised that the public lighting of a city should be under the control of a single expert, and not referred to those who had many other duties to attend to.

There was no doubt that great improvements had been made in methods of lighting on some railways, and he knew of cases where the expert appointed to attend to this matter had been able not only to provide better illumination, but to make substantial economies as well. But as had been remarked in the discussion one could still see many examples of bad lighting, and many opportunities for improvement.

Mr. J. S. Dow (*communicated*): I should like to endorse Mr. Cunnington's view regarding the lighting of third-class stations. No doubt we should welcome improvements; but the illumination of important stations is a much more urgent matter and it seems best, as Mr. Campbell said, to concentrate attention on these cases where advances would be fully justified. In this connection there is one aspect that seems to have been somewhat overlooked in the discussion, the use of light for publicity. The Underground has set a good example in this respect, but some of the main terminal stations of surface railways have little to indicate their existence by night. Surely it is obviously to the interest of a great railway company to arrange, by the use of illuminated signs, by imposing lighting of station approaches, and other methods that its important stations become landmarks at night, instead of gloomy buildings recognised by a stranger only with difficulty.

In regard to railway carriage lighting, my own impression is that the need for improvement is much greater on most surface railways than on the tubes. But the use of bare lamps is a bad feature.

Mr. E. A. Marx (*in reply*): I should like to thank the meeting for the cordial way in which they have received our paper. On one or two points raised in the discussion I should like to make a few remarks.

It was mentioned that an illumination of 0·2 to 0·3 foot-candles on station name-boards was at present quite sufficient to enable the name to stand out, especially as name-boards are usually placed at the end of the station. Surely, though this is rather low, 0·2 foot-candles is a very low illumination, and, as the name-boards are not very big, a considerably higher illumination could be provided by means of an efficient reflector, but with little or no increase in the size of lamp.

The importance of station name boards deserves local illumination being provided, and given this necessity it is as easy to provide 10 foot-candles as it is 0·2 and far more effective.

A reference was made to the possibility of installing axle generator sets on electric railways. I might mention that on a certain foreign railway, equipped from England, this is now being done. The track voltage is 1,500 v. D.C., and it was found that the only efficient way out of the difficulty was axle generators giving a low voltage for lighting purposes.

Several speakers have used the word "shade" and not "reflector." I should like to emphasise this point, that "reflectors" are efficient, scientifically designed fittings which will re-direct the light where it is required. "Shades" only shield the lamp, but "reflectors" do more, they re-direct the light efficiently and the term implies a much better outlook on the subject.

Reflectors need not be ugly, even if not objects of beauty, they can present quite a good appearance combined with efficiency. Efficiency and appearance are not incompatible, but they can quite well be made to combine for the best effect. While on this subject, mention might be made of the low cost, due to the cheapness of energy, of increase of light on electrified railways. This is a most important point in favour of good illumination.

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TOPICAL AND INDUSTRIAL SECTION.

[The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

ARTIFICIAL DAYLIGHT AT THE ZOO.

A novel application of "artificial daylight" is the installation of Siemens Daylight electric lamps in the new aquariums under the Mappin Terrace at the Zoological Gardens. There are in all 95 show tanks, each with a varied and picturesque background modelled by Miss Joan Proctor, F.Z.S., and those on the inner side of the gallery are illuminated by gasfilled daylight lamps, having tinted glass of the kind familiar to our readers. The results are stated to be quite successful, the fish and their surroundings being clearly revealed, and apparently plants and fish flourish in the artificial light as well as in daylight.

BENJAMIN BULLETINS.

The second (February) issue of the BENJAMIN BULLETINS deals chiefly with commercial illumination, a feature being a series of attractive photographs, taken by artificial light, of show-windows, offices, etc. An article on Modern Show Window Lighting puts the case for good illumination quite convincingly. Other features include a good view of the sign of the "Angloco" petrol service station, illuminated by Benjamin reflectors, giving very uniform distribution. There is also a striking illustration showing the effect of the scheme recently carried out by Benjamin Electric and Siemens and English Electric Ltd. for the illumination of a football ground—an enterprising and novel departure in lighting.

Fig. 1.—Gas lighting at Reading station showing obsolete system on left and the new system with inverted burners on the right.

GAS LIGHTING ON THE GREAT WESTERN RAILWAY.

A recent issue of A THOUSAND AND ONE USES OF GAS contains some interesting particulars of the use of gas, both for lighting and other purposes, on the Great Western Railway. In the vast locomotive, carriage and wagon works at Swindon thousands of inverted gas lamps have been installed, and gas is also used for firing furnaces and many heat-treatment processes. Gas is again used for driving generators which supply much of the electricity required by the works.

Several interesting examples of platform lighting are also appended. Thus, Fig. 1 shows on the left the obsolete gas lighting at Reading station, on the right the new system with inverted burners, which shows a very marked improvement. Fig. 2 shows the conditions at Newton Abbot station. The photograph was taken on the night when the new conditions—involving superheated low-pressure inverted lamps—were installed. It is estimated that the new lamps give 50 per cent. better light than those formerly used.

Attention is drawn to several other

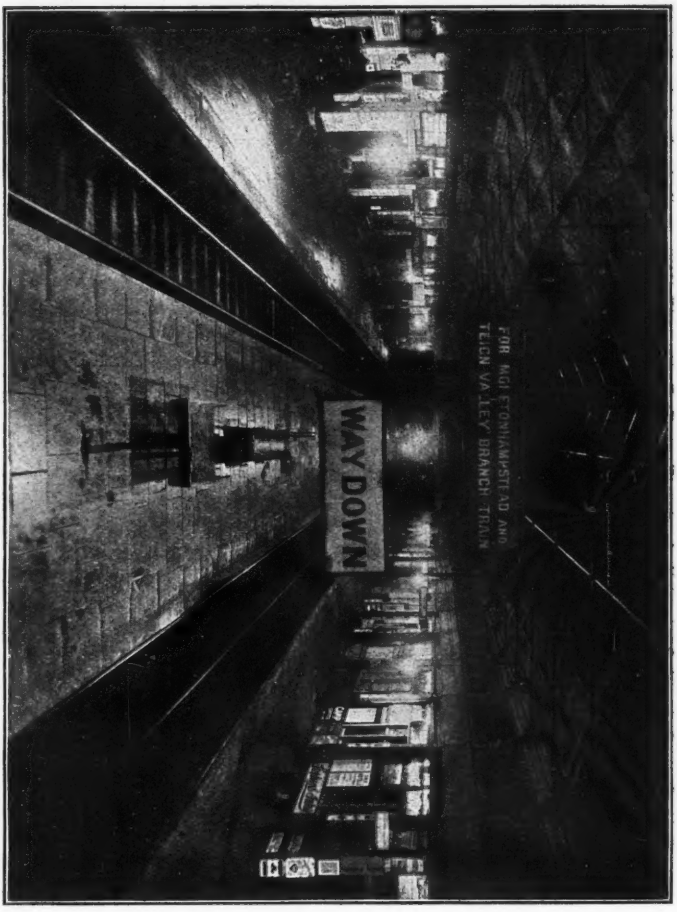

Fig. 2.—Showing the new installation at Newton Abbot station.

special devices, amongst which may be mentioned the fitting of station name-plates to the lanterns in stations at Ealing, Reading, Newton Abbot and elsewhere. We are glad to note that the need for some device enabling passengers to see the names of stations at night is now receiving attention from leading railway companies.

THE LIGHTING OF THE NEW TIVOLI KINEMA THEATRE.

A well got-up booklet has been issued by the General Electric Co., Ltd., describing the lighting of the above theatre, which was recently described in this journal. The booklet is illustrated by some effective colour-prints showing the special lighting effects achieved. The first of these gives an idea of the appearance of the façade when flood-lighted. Then there is a picture showing the design of the projectors used. Next we have views of the ceiling and auditorium showing the mingling of amber, blue and rose in the colour scheme provided. Thus, in the coloured picture of the ceiling the large central dome is

illuminated in blue, with a small central secondary dome in amber, whilst other adjacent dome-recesses glow with rose-coloured light, and there are also small recessed lights behind discs of diffusing glass which give various colours. The installation furnishes an indication of the modern tendency to break away from stereotyped methods and utilise colour and concealed lighting for the illumination of kinema theatres, and we understand that the scheme also represents an instance of effective co-operation between the illuminating engineer and the architect—in this case Mr. Bertie Crewe.

GAS EXHIBITS AT WEMBLEY.

Readers will note with interest that although the uses of electricity are illustrated on a very large scale at Wembley Exhibition, gas is also well represented. The lighting of the Amusements Park is being done with this illuminant, and a special Gas Exhibit, to which nearly all the gas undertakings in this country and a number abroad have subscribed, is being arranged.

We understand that the Domestic Section will include a series of living pictures illustrating "the Seven Ages of Woman" from infancy to old age. Mannequins will explain, in the capacity of children's nurse, college girl, business woman or housewife, the cardinal fuel problems of each Age and how gas can help in their solution. The Executive Committee, under the chairmanship of Mr. F. W. Goodenough, are aiming throughout at co-operative effort so that the exhibit may form a representative harmonious whole.

THE WELSBACH SPRING LIST.

The Welsbach Spring List (No. 446) as usual covers a wide ground. Oil, gas and electricity are all represented in the sections dealing with heating and cooking appliances. The line of wall mirrors is stated to form an entirely new departure in construction. The frame is in one piece, and of brass, and thus will not warp, and the back of the mirror, of enamelled steel, is so constructed that no packing (liable to harbour moisture) is needed. Attention is also drawn to the extended range of pressed glassware for which an exceptionally clean finish, closely resembling that of genuine cut glass, is claimed.

We are also asked to mention that the Leeds depot of the Welsbach Light Co., Ltd., has been removed from 6, Quebec Street to much more extensive premises at 46, Park Place, Leeds, where all Welsbach lines will be on view.

ORNAMENTAL STREET LIGHTING.

Much has been said recently regarding the importance of good public lighting in the interests of safety of traffic and public convenience. It is to be hoped that we are now approaching a period when more attention will also be devoted to the question of appearance of lighting fittings. A catalogue that has reached us from the Westinghouse Electric and Manufacturing Co. (Indiana, U.S.A.) contains illustrations of some pleasing ornamental brackets, newels and lanterns, many of which are suitable for use outside public buildings. In all cases diffusing glassware is used and the metal work is of massive and substantial design. In a leaflet entitled LIGHT ON THE HIGHWAY a special bracket light capable of adjustment so as to alter the main angle of inclination, according to the width of the road, is described. A reflector concentrates light downwards and the rays thus directed are received and distributed by a double set of refracting prisms. Attention is drawn to the importance of uniform illumination, which this form of highway unit is specially designed to achieve.